Economic Impacts of Climate Change: Some Observations

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Overview

- Aim is to review some of the lessons from the CalEPA/CEC Scenarios Project.
- Existing national economic models assume perfect foresight, smooth transition to a warmer climate.
  - EPA's CCRAF model of the US economy.
  - William Nordhaus model of world economy (OECD).
- Models typically project modest costs from climate change.

Overview

- Key innovation in Scenario Project was detailed spatial downscaling.
- Key Lesson from this:

  BEWARE AVERAGING
- Nonlinearities & thresholds occur at quite fine scale of spatial and temporal resolution. Using broad spatial and temporal averages is highly misleading.
- This matters greatly both for measuring economic impacts and for designing adaptation policy.

An example: what is the increase in temperature?

HOW TO CHARACTERIZE THE CHANGE IN TEMPERATURE, 2070-2099, USING HADCM3			
		EMISSION SCENARIO**	
		A1fi	B1
Change in global average annual temperature		4.1	2
Change in statewide average annual temperature in California*		5.8	3.3
Change in statewide average winter temperature in California*		4	2.3
Change in statewide average summer temperature in California*		8.3	4.6
Change in LA/Sacramento average summer temperature		~10	~5
Extra # of extreme heat days in Los Angeles/Sacramento		100	30
*Change relative to 1990-1999. Units are ˚C			

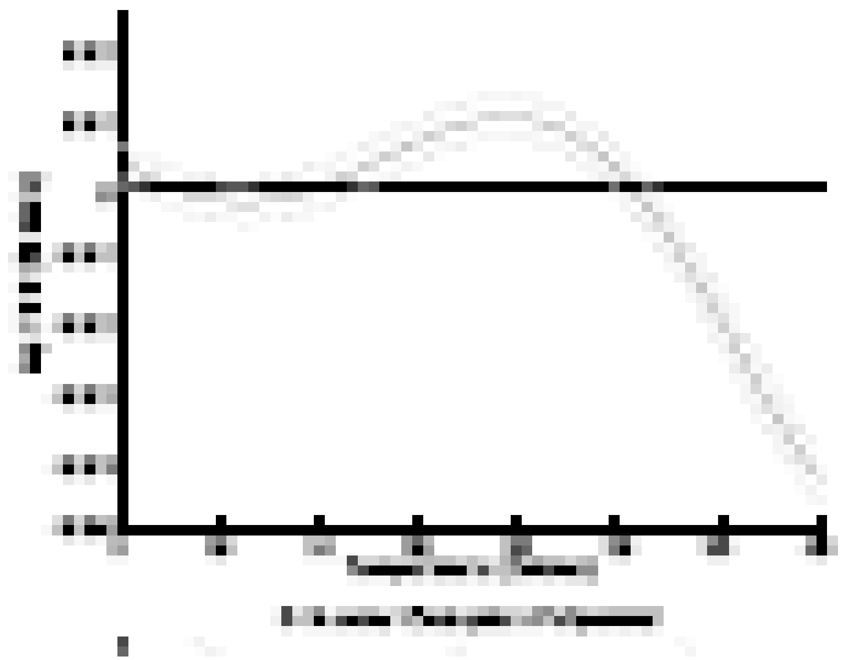
Why variation matters

- The nonlinearity of the damage function means that the aggregate damage is larger than if one simply assesses the damage corresponding to the average temperature change.
- Fenchel's inequality: if D(x) is concave,

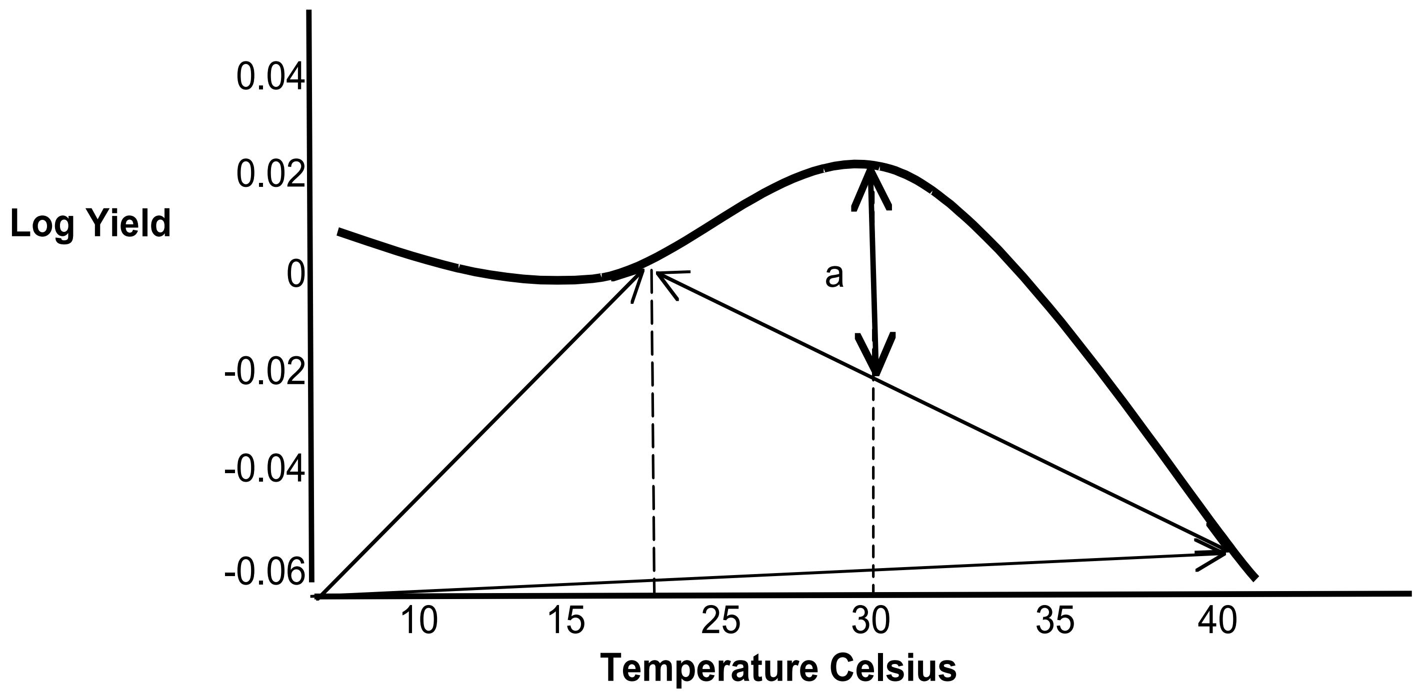
$$E\{ D(x) \} > D(E\{x\})$$

Schlenker & Roberts (2006) Relation of Temperature and Crop Yield

- Relationship is not symmetrical; it is distinctly asymmetric, fairly flat at first and then sharply declining beyond an upper threshold.



Non-linear relationship between temperature and yields and Fenchel's inequality



Climate, water & agriculture

- The standard view in the literature on the economic impact of climate change on US agriculture is that (1) precipitation is the key variable to focus on, rather than temperature, and (2) “wetter is better.”

- Disagree on both counts. Spatial and temporal considerations lead to a different perspective.

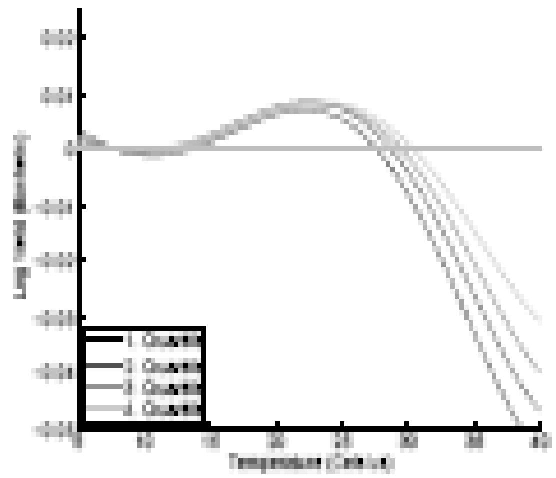
Importance of spatial and temporal details for water supply

- 2/3 of precipitation occurs north of Sacramento.
- About 2/3 of all water use occurs south of Sacramento.
- 80% of precipitation occurs October-March.
- 75% of all water use occurs April – September.
- Snow pack holds the equivalent of ~1/3 of our major storage capacity

- In California, changes in winter precipitation are far less significant economically than changes in temperature.
  - Water is not a scarce resource in the winter.
  - To make winter precipitation an economically valuable asset requires an investment in some form of storage.
  - Unlike precipitation, changes in winter temperature directly affect spring and summer water supply.
- Economically, it is the change in temperature that is especially significant for California.

Effect of temperature much larger relative to precipitation

Figure 6: Nonlinear Relation Between Temperature and Corn Yields By Precipitation Quartile



Notes: Panel displays Chebyshev-polynomials between the effect of each 1-day time period at a given temperature in the growing season and yearly log yields by precipitation quartiles for the months June and July.

Institutional variation

- Water supply in CA is managed by ~300 individual agricultural and urban water agencies.
- They are quite distinctive. They have different sources of supply, different water rights, different economic needs, and they are independently managed.
- Given this heterogeneity, a top-down (averaged) approach to impact analysis produces different implications than a bottom-up (disaggregated) approach.

Example: Delta Seismic Risk Study, 6/05

- Total urban water use in the SF Bay area is ~1 MAF. About 1/3 of this comes from CVP and SWP.
- In seismic scenario, CVP and SWP cease pumping through Delta cease for 2.3 yrs.
- For some urban districts, this is a loss of as much as 80% of their water supply. For about half the population, there is no loss of water supply. The overall average urban loss is 1/3.

Implication

- The economic impact of the disruption is different when viewed top-down vs. bottom-up because of the differences in individual supply portfolios.
- If there were full regional coordination and sharing of water supplies, the losses would be minimized.
- Regional coordination is not costless, politically or economically: plumbing inter-connections need to be paid for; this is part of the cost impact.

Tail probability events & the need to look at the full distribution

- Damages increase non-linearly with severity of supply reduction
- Adverse impacts of climate change are likely to be disproportionately larger in the worst years
- Hence, the worst years get worse.

CVP South of Delta Annual Deliveries under climate change scenarios PCM B1-A2 and GFDL B1-A2 for 2070-2099

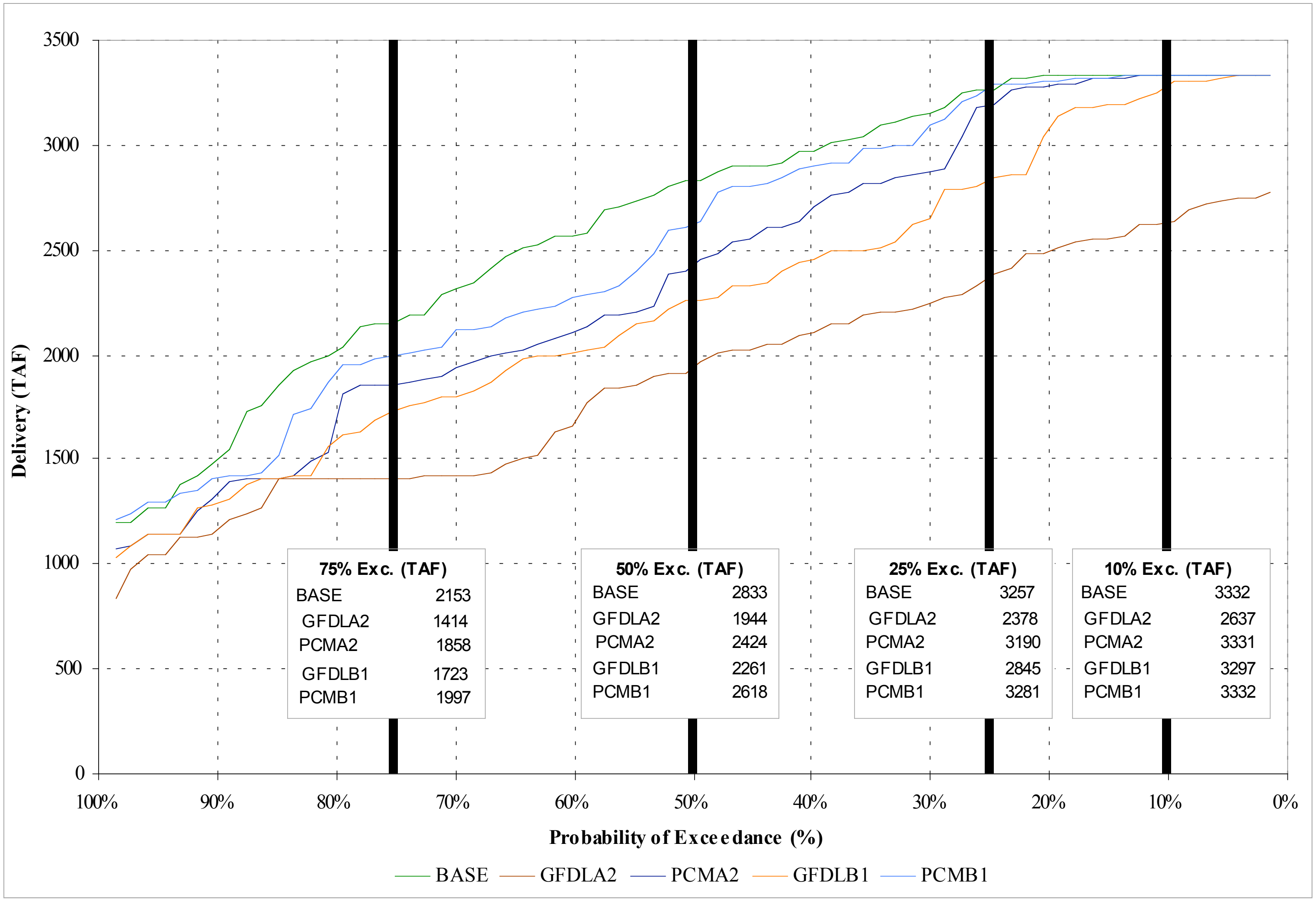


TABLE 1. CHANGE IN SURFACE WATER AVAILABLE TO AGRICULTURAL WATER USERS IN THE CENTRAL VALLEY, 2070-2099			
	REGION		
	Sacramento Valley	**San Joaquin Basin**	**Tulare Lake Basin**
APPLIED WATER USE IN 2000 (TAF)	7,735	7,358	10,879
% Surface water	64%	74%	60%
% Groundwater	36%	26%	40%
CHANGE IN SURFACE WATER AVAILABILITY 2070-2099			
(Surface water with climate change/surface water used in 2000)			
YEAR CATEGORY			
Upper 50% of years	98%	91%	90%
Next 35% of years	90%	52%	51%
Lowest 15% of years	47%	33%	30%
Average of all years	88%	69%	67%

Economic impacts under GFDL A2 – water supply

- By 2085, in an average year, 9% loss of net revenue in Central Valley agriculture; 26% reduction in lowest 15% of years.
- By 2085, urban shortages in Southern California occur twice as frequently and are about twice as severe; in about 35% of the years, rationing could cause loss averaging $5 + billion/yr for water users.

Insurance: an additional component of the economic cost

- With perfect foresight, the cost of adaptation can be minimized. E.g. purchase water from water markets only for months where there is a supply shortfall; purchase no more than the amount of the shortfall.
- With uncertainty (imperfect foresight), adaptation will be more costly.
- With risk aversion, adaptation will become even more costly adaptation. Water users will want to buy the equivalent of insurance.
- With insurance, costs are incurred in years where they turn out not to be needed.

Energy: another example of the fallacy of misplaced aggregation

- Conventional economic analyses of the impact of climate change focus on operating costs (not capital expenditures). The find a reduction of expenditures on heating, but an increase for cooling.
- The typical conclusion is that this is roughly a wash.
- This ignores the need for expenditures on appliances (installing air conditioning).

Spatial relocation of production

- For example wine grapes.
- But mistake to assume there is perfect substitution between one location and another.
- Mistake to assume the relocation would be costless.

Decreasing Wine Grape Quality

Temperature Impacts

	1961-1990	2070-2099			
	Current Conditions	Lower Emissions (B1)		Higher Emissions (A1fi)	
		PCM	HadCM3	PCM	HadCM3
Wine Country	Optimal (mid)	Impaired	Marginal	Impared	Impaired
Cool Coastal	Optimal (low)	Optimal (mid-high)	Optimal (mid-high)	Optimal (high)	Impaired
Northern Central Valley	Marginal	Impaired	Impaired	Impaired	Impaired

Wine Country (Sonoma, Napa Counties)
Cool Coastal (Mendocino, Monterey Counties)
Northern Central Valley (San Joaquin, Sacramento Counties)

Extreme events

- With extreme events (heat waves, floods, coastal storms) the consequences spill over to the larger economy, not just climate-sensitive sectors (agriculture, forestry, water, energy).
  - There is property damage
  - There is disruption of normal production

Coastal flooding

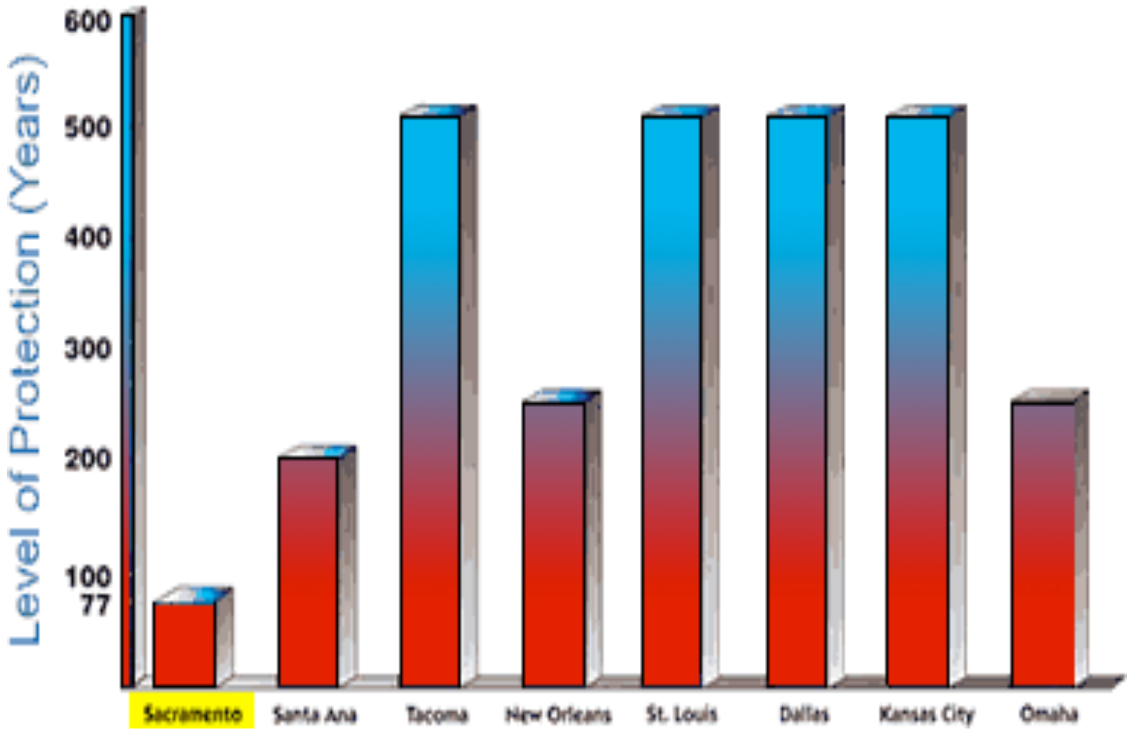
- Extreme event are where the hourly sea level height lies above the historical 99.99% level for the period 1960-1978 (i.e., hourly sea levels *lower* than this were experienced 99.99% of the time).
- Such extreme events tend to occur when heavy winter storms coincide with high tides, as happened in 1982-83 and 1997-98.
- The frequency of such events escalates sharply as the sea level rises.

Potential for damage from coastal flooding

- By the end of the century (2070-2099), if the mean sea level at San Francisco does *not* rise above what it was in 2000, an extreme hourly sea level event would occur about **15-20** times (hours) per year in San Francisco.
- If the mean sea level at San Francisco rises by 20 cm between 2000 and 2100, an extreme hourly event would occur about **150-200** times per year in San Francisco.
- If it rises by 40 cm, an extreme hourly event would occur about **1,500** times per year.
- If it rises by 60 cm, an extreme hourly event would occur about **7,000** times per year.
- If it rises by 80 cm, an extreme hourly event would occur about **20,000** times per year.

Flood Risk in the Sacramento Valley

- Even without accounting for climate change, Sacramento faces a very high risk of flooding – and much more so with climate change.



California's inland flood threat

- Little meaningful economic analysis.
- Little meaningful risk assessment, accounting for social/response risks as well as engineering/hydrology risks.
- Narrow emphasis on seismic events in Delta overlooks
  - Seismic threats to levees elsewhere in CA
  - Population growth & changing land use
  - Geriatric aging of levees & dams
  - Climate change

CONCLUSIONS

- Existing estimates are likely to significantly understate economic cost of climate change impacts in California.
- They focus on equilibrium; they downplay costs of adjustment and adaptation.
- They ignore impacts on capital assets.
- They ignore costs associated with uncertainty and risk aversion.
- They ignore non-market impacts.